UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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MEMORANDUM

Date: November 29, 2018

Subject: Improving Resolution and Technical Basis for CSM Relative to Main Street and Jewel Drive DAPL Pools, Olin Chemical Superfund Site (OCSS or Site), Wilmington, MA.

To: Jim DiLorenzo, Lynne Jennings, Chris Smith and Jennifer Lambert (Nobis)

From: Bill Brandon

Introduction:

The memorandum, below, supplements EPA's November 15, 2018 memorandum entitled, *Follow-up to Meeting of October 25, 2018: Reevaluation of Technical Basis for "Main Street Saddle" and related CSM elements, initial response,* and provides additional technical clarification on EPA's position regarding the Main Street DAPL pool, Main Street "Saddle" and "Spillway" features, the pilot DAPL extraction system at Jewel Drive, and related issues.

The degree of resolution provided by the current Site data set is a key limitation, as it determines the quality, accuracy and veracity of any CSM built from it, as well as the uncertainty associated with it. At OCSS, there are many fundamental issues relative to the adequacy of data and resulting uncertainties, including:

- Data Density
- Spatial resolution
  - Lateral
  - Vertical
- Temporal variability vs. measurement frequency of key parameters
- Measurement uncertainty (i.e., "error bar") for a range of variables.

These issues are discussed further in the comments below, generally, as well as in specific instances where the CSM is not sufficiently resolved due to one or more of these issues. Identification of these resolution limitations and uncertainties inherent to the current CSM point to specific recommendations for follow-up actions, such as additional data collection and/or analysis which can improve resolution and refine the CSM in key locations. It must be emphasized that refinement of the CSM is not needed for the purposes of developing and evaluating alternatives in the feasibility study for source control. The current CSM demonstrates that there are current ongoing and uncontrolled sources and there is sufficient data to conceptualize and evaluate the range of alternatives that can address these sources. If a remedy is selected for source control, a more highly-resolved CSM is a critical project objective for designing the most effective remedial source control measures in the most advantageous configurations. For example, it is possible to develop and evaluate an alternative that extracts DAPL and highly contaminated groundwater in the Main Street DAPL pool area. The feasibility study for source control can make informed assumptions regarding the number of wells needed to provide for effective extraction. However, if a source control remedy is selected, a more refined CSM is needed during the design of such a system to better determine the most effective location and configurations of the extraction wells. This memo provides general and specific recommendations for follow up work that will be essential to refine the CSM in this regard below.

This memo also includes a discussion of the issues regarding source control measures, ‘stable’ vs ‘unstable’ DAPL sources, ‘hot spots’, as they relate to the central issues of bedrock structure, configuration and fracturing, particularly the shape of the top of bedrock (TOR) surface and its ability to facilitate or impede DAPL and/or dissolved contaminant migration relative to the Main Street area. It is important to note that the relationship of the TOR surface relative to position, thickness and shape of significant DAPL sources/pools is a key aspect of the CSM that is needed to support remedial design. Recommendations to better understand TOR morphology in relation to DAPL pool morphology should therefore not be viewed as another characterization step, but rather as a high-priority design data collection effort to support remedial action after completion of the NCP remedy selection process. EPA believes groundwater extraction has already been demonstrated to be an effective technology relative to source control - even without the benefit of a more highly-resolved data set or detailed evaluation of extract methods and well configurations, and this technology should provide a basis for optimized extraction designs and strategies.

General Comments:

1. *General CSM Data Quality Issues*: The comments below further address the following issues as they relate to the larger CSM relative to DAPL and highly contaminated groundwater fate and transport, particularly in relation to the bedrock. While the following data collection methods are generally acceptable, the claimed precision and over extrapolation of the results is of concern.

    - General Issues regarding adequacy of data density, spatial resolution and temporal variability

    - Uncertainty regarding estimated DAPL pool elevations and thickness
        - Conductivity Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
        - Induction Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
        - Direct sampling of DAPL from multiport wells - Measurement Accuracy, Precision, and other Issues

    - Lateral and Vertical Resolution regarding top-of-rock estimations by a variety of methods and resulting uncertainties
        - Soil Borings and Conventional Drilling Methods
        - Direct Push Methods
        - Rotosonic Drilling
        - Seismic Reflection
        - Seismic Refraction

    - Temporal Variability of Various CSM elements vs. Measurement Frequency

2. *Spatial resolution (general)*: A common problem to many of the central elements of Olin's CSM regards the lack of spatial resolution inherent to much of the Site data set. Overreliance on spatially limited data can result in significant errors. A CSM which combines and compounds such errors may ultimately diverge from reality in substantial and significant ways. For example, under most circumstances, data collected from a single bedrock location should not be used to speculate what conditions may exist hundreds of feet away at a different location. Such speculation would be risky at a "simple site", let alone a complex site such as OCSS. The degree of spatial resolution must also be commensurate with the complexity of the Site's subsurface. These issues reach critical importance regarding bedrock characterization, interpretation, and CSM development at OCSS due to the degree of folding and faulting and overall complexity of the Site. This issue is discussed further in context, in the comments below, regarding specific technical issues.

3. *Spatial resolutions and CSMs*: The issue of spatial resolution - and the adequacy thereof to support a CSM – is critical and preeminent when evaluating bedrock conditions beneath the Main Street area, or for that matter any portion of the OCSS subsurface. It must be acknowledged that the area affected by the OCSS is immense. In most areas at OCSS, the density of characterization data (borings, seismic, etc.) is arguably weak, particularly in bedrock. For instance, Olin often makes comparisons, inferences, and draws conclusions by comparing conditions from wells in the Main Street area with "*downgradient wells*". In bedrock, the nearest down-gradient well to the Main Street area is on the order of the length of one or more football stadiums away, i.e., many hundreds of feet. This is an inappropriately far distance for direct comparison, even in areas with simple geologic conditions. As such, elements of the CSM which rely on trend comparisons, or other comparative means to draw conclusions or inferences relative to the two areas are "*fuzzy"* at best, and at worst incorrect or misleading. This issue is a specific example of the types of general assertions and assumptions which pervade Olin's CSM, and often do not have any substantive data to support them. The reality may be much different.

   The purpose of this discussion is not only to point out the general pitfalls of "over projecting" assumed conditions over huge lateral and vertical distances, but also to point out that it is premature to propose a particular sampling strategy - *based on the existing well network* - which can elucidate the veracity of the current CSM in the Main Street area regarding DAPL pool elevations, bedrock elevations, and linkages to conditions measured in downgradient groundwater. EPA has stated in previous comments that the downgradient monitoring network relative to the Main Street area is deficient, and in need of augmentation, particularly with respect to bedrock. As a first step, a more resolved depiction of the TOR surface in the Main Street area is needed as well as the elevations, and thicknesses, and lateral extent of all DAPL pools in this area. This is not a trivial undertaking, but such information is needed to inform subsequent efforts to augment the existing well network in key locations and depths "downgradient" of key areas of DAPL accumulation or other contaminant "hot spots" in the Main Street area.

4. *Lateral and vertical resolution on TOR surface*: Frank acknowledgement of such resolution issues is needed to assess the *adequacy* and *uniqueness* of the interpretations which have been used historically to define the "*Main Street DAPL pool*", "*Main Street Saddle*", and other similar features of note at the Site. It is EPA's observation that the complexity of the bedrock surface is

more variable than these simplistic interpretations allow. For example, upon examining the bedrock surface map created for the Main Street area by Geomega, and later revised by EPA, the presence of crenulations and variability on the TOR surface over lateral distances of 10's of feet are seen in nearly all areas where seismic reflection data was collected with a relatively close geophone spacing (~ 30-foot spacing). On the other hand, where data density is low, resolution of second-order features on the TOR surface is limited at best. This suggests lateral variations on bedrock elevation on a similar scale (or finer) than the lateral spacing of the characterization data points should be expected. On the other hand, the technical basis for the "Main Street saddle" is based on three borings spaced on the order of 75 to 100 feet apart, laterally. Cleary such a sparse lateral spacing is not commensurate with the level of variability observed in nature at OCSS or the level of resolution offered by other laterally-integrative methods such as seismic reflection. It must also be acknowledged that there are large swaths of area on the interpretive TOR surface used to define the "*Main Street Saddle*" and "*Main Street DAPL pool*" where there is no data of any kind. These issues of lateral resolution and data deficiency also call into question the validity and uniqueness of the interpretations which have been used to define the other DAPL pools on the Site, such as the Jewel Drive pool, as well the geologic features which are presumed to exist in the intervening areas between the pools. These issues are discussed further in the comments, below.

5. *Alternative Conceptualization of DAPL "Pool" areas*: Based on the foregoing discussions, it may be more appropriate to conceptualize the major *general* areas of DAPL accumulation as composite *source areas* with many *smaller laterally disconnected depressions* in which DAPL has accumulated rather than large monolithic basins. As such, all depressions on the TOR surface need not be characterized identically as uniform, unfractured, and "tight" (i.e., impervious) which inhibit DAPL penetration to greater depths. As will be discussed in the comments below, data do not support this overly simplified model. Instead, the larger-scale depressions may simply reflect an area - which at finer scales of investigation - reveals many *distinct crenulations and depressions of varying dimensions and inconsistent elevations*. Fracturing may or may not connect the TOR surface in these crenulations with deeper parts of the bedrock system. The attached Figure 1b., presents such an alternate CSM for areas of DAPL accumulation, similar to the Main Street DAPL area, for comparison with the generalized DAPL pool CSM presented previously by Olin (Figure 1a). Additional comments, below, will address the technical merits for these competing conceptualizations relative to features of interest, starting with the Main Street DAPL pool.

6. *TOR Elevation Uncertainty - Main Street Area*: Uncertainties on the data elements used to map TOR surface were discussed in some detail in EPA's November 15, 2018 memo, entitled, *Follow-up to Meeting of October 25, 2018: Reevaluation of Technical Basis for "Main Street Saddle" and related CSM elements, initial response*. The following table compiles and summarizes this information:

Data Type	**Vertical Resolution Typical range (ft)**	**Vertical Resolution Best Case (ft)**	**Vertical Resolution Worst Case (ft)**	**Comment**

Direct Push Boring	< 1 – 10+	<1 ft	10+	Potential error bar can be large due to potential drill string drift, “false positive” identification of bedrock at shallow “refusal depth”, etc. Error usually biased high, i.e., to (falsely) higher bedrock elevations than actual conditions.
Soil Boring or MW (w/o confirmatory Core Samples)	<1 – 5+	<1 ft	5-10+	Degree of resolution dependent core recovery and coring methodology. Lack of confirmatory core can result in large errors due to mis-identification of boulders as TOR, false/premature refusal depths, etc. Note that boulders were identified during slurry wall construction and in a number of boring logs around the OCSS, so in this case, boulders are a serious non-hypothetical concern.
Soil Boring or MW (with confirmatory Core Samples)	<1 -5	<1 ft	5*+	SB-8 is a “best case” point as confirmatory core samples were collected here. Degree of resolution dependent on coring method, recovery, and ability to resolve transitional material contacts from till to weathered bedrock to competent bedrock. *Assumes 5-ft core sample with negligible recovery.
Seismic Reflection	<5	<1 ft	1 - <5	Method is generally superior than refraction, but associated error bars are not known, are site-specific and generally better than refraction. A rigorous assessment of site-specific reflection data quality has not been made for this memo.
Seismic Refraction	5+	<1 ft	5-10+	A vertical error of 10 % (or greater) of overburden column thickness is typical. However, reporting for the OCSS seismic surveys conducted for the MSDP area suggest even poorer resolution for these surveys due to site-specific factors.

7. *Preliminary Assessment of Spatial Resolution of TOR surface at Main Street DAPL pool:* Given the TOR uncertainties for the various data types presented in the previous comment, a preliminary assessment of spatial resolution of the TOR surface beneath the Main Street DAPL pool is presented below. To complete this preliminary analysis, the area underlying the mapped outline of the Main Street DAPL pool, as shown on Figure 2.2-9 of the OU3 RI, was divided into two sections, north and south, as shown on the attached Figure 2. The borings, monitoring wells, direct push probe locations, and seismic stations shown on Figure 2.2-9 were totaled and used to prepare the following summary tables.

Box 1: (Northern Portion of Main Street DAPL pool)
Dimensions: 825 X 525 feet
Total Area: Approximately 433,125 SF (***9.9 acres***)

Box 2: (Southern Portion of Main Street DAPL pool)
Dimensions: 525 X 525 feet
Total Area: Approximately 275,625 SF (***6.3 acres***)

BOX 1						
Data Type	**Number of Points**	**Points per Acre**	**Acres per point**	**Lateral Spacing (min) feet**	**Lateral Spacing (max) feet**	**Comment**
Soil Boring	3	0.303	3.3	75	100	
Direct Push Boring	9	0.91	1.1	37	300	
Monitor Well	3*	0.303	3.3	638	825	
Seismic Reflection MP's	25	2.5	0.39	30	525	
Seismic Refraction Lines	375 LF					Not Included in Analysis due to questionable data quality
ALL PTS Total (excludes Refraction data)	40	4.04	0.25	0	300	

BOX 2						
Data Type	**Number of Points**	**Points per Acre**	**Acres per point**	**Lateral Spacing (min) feet**	**Lateral Spacing (max) feet**	**Comment**
Direct Push Boring	4	0.63	1.575	150	500+	
Monitor Well	2	0.32	3.15	244	450+	

Seismic Reflection MP's	5	0.79	1.26	30	>>300	No control in y-dimension
ALL PTS Total	11	1.7	0.57	30	500+	

Basic conclusions from this analysis suggest that lateral resolution in the Main Street DAPL pool area - at best - are on the order of:

- One data point per quarter acre (northern portion)
- One data point per half acre (southern portion)

Combining this with the forgoing analysis of vertical resolution yields the following summary table regarding the spatial resolution on the TOR surface in the Main Street DAPL area:

- Lateral resolution: 0.25 to 0.5 acres (or greater)
- Vertical Resolution: < 1-foot (best case) to > 10-feet (worst case)

One must acknowledge that the Main Street DAPL area is a critical element of the Site CSM. One must also conclude that it is under-characterized for the purposes of demonstrating that the system as a whole, acts to control source migration. Additional resolution is needed. Even a cursory examination of this information inevitably leads to a conclusion that the Main Street DAPL area is woefully under-characterized, by just about any standard. Consider that a "typical" small UST site on the order of ¼ acre in size would typically require 3 to 4 monitoring wells, *at a minimum*. This would suggest an average lateral data density of 3 or 4 times that of the Main Street DAPL area. Even when considering the TOR surface as the only data objective, (which it is not), one would expect a much higher level of resolution on par with other significant source zones in bedrock, e.g., the Quarry and ES/JEBS sites at Loring AFB, Building 81 at NAS South Weymouth, etc. where data density is on the order of 50 to 100 points or more per acre in the high concentration source areas. If a remedy is selected for source control, additional effort will be needed to better understand the level of complexity of the TOR surface at the Main Street DAPL area, as a first order design data objective, to ultimately couple these data with more highly resolved assessments of DAPL occurrence, location, elevation and thickness to formulate a comprehensive and effective source control remedial action. See recommendations, below.

8. *Revised interpretation of TOR surface in Main Street DAPL*: A revised interpretation of TOR surface in the Main Street DAPL area showing features of interest and data gaps is included on the attached figures. Figure 3 is a map of the TOR surface in the Main Street area. Figure 4 is a cross section West of Main Street (B-B'), and Figure 5 is another north-south cross section aligned east of Main Street. It is interesting to note that the revised figures, which account for the error bars on the TOR data discussed in prior comments, allow room for an interpretation which identifies the Main Street "Saddle" as a smaller feature within a region of relatively higher bedrock elevations. This region is designated provisionally as the Main Street "Pinnacle". As per this interpretation, there also appears to be a small disconnected depression on the bedrock surface in the general area of MP-3, which is designated provisionally as the Main street "Chalice", which EPA interprets as an isolated depression of higher elevation than the average elevation of the Main Street DAPL pool. DAPL presence at this higher elevation may be due to its apparent morphology as a closed depression of

smaller scale, possessing an interpreted comparatively "tight bottom" - with a relatively sparse degree of fracturing - that only allows for limited excursion/migration of DAPL, at slow rates.

The resolution of this feature is weak given the limited data to the north and east. Additional seismic data proposed in Recommendation 3, below, will help to clarify the presence and dimensions of this feature. In the revised interpretation, the "spillway" feature previously identified by EPA has been moved slightly to the south to honor the seismic refraction data, but data quality issues have been identified with the refraction data, and a closer examination of that data does *not* support elimination of the "Spillway". To the south of the "Spillway", an additional area of relatively higher elevation bedrock, provisionally designated the "Plateau" has been identified. South of the "Plateau", a smaller scale depression/trough designated as the "Southern Slot" has been identified and is located within a larger-scale depression herein designated as the "South Drainageway" feature. The potential importance of these low-lying valley-like features strongly suggests the need for further resolution in this southern part of the greater Main Street DAPL area. Further data collection is proposed below (See Recommendations), to allow for improved resolution on the TOR surface in the Main Street DAPL area to confirm the presence, dimensions and elevations of these features as well as to refine the CSM to appropriately inform remedial efforts. Please see associated figures, attached. Again, the presence of these features further supports the need for evaluating source control actions that minimize the migration of both DAPL and highly contaminated groundwater. If a remedy is selected for source control, the recommended data collection efforts will be needed to support the design of effective source control remedial measures.

9. *DAPL measurement Error Bars, Issues, and Uncertainties*: EPA's assessment concluded that the various approaches used to measure DAPL, although helpful for providing rough estimates of the volume, all have significant issues, error bars, and uncertainties associated with them. As such, they are not accurate enough to provide precise elevation depths and therefore, additional approaches will need to be employed in conjunction with follow-up efforts. As summarized above, these issues include the following:

- Uncertainty regarding estimated DAPL pool elevations and thickness
- Conductivity Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
- Induction Methods for DAPL estimation - Measurement Accuracy, Precision, and other Issues
- Direct sampling of DAPL from multiport wells - Measurement Accuracy, Precision, and other Issues.

The following table compiles our assessment of the various accuracies, error bars, and other uncertainties associated with the various methods.

DAPL Estimation Method	**Vertical Resolution (Tool or Probe)**	**Vertical Resolution/Error Bar (DAPL surface)**	**Comment**
Conductivity Probe	0.05 ft	1 ft – 10+ ft	Magnitude of error bar is correlated with length of screened interval/sand pack in specific monitoring well.

Induction logging	0.1 ft	>> 5+ ft	Dependent on specific dimensions of EM logging tool; further analysis is forthcoming. The likely confounding effects of reported solid precipitates (such as chromium sulfates) in the aquifer matrix relative to resolving DAPL elevation with Induction logging have not been quantified for this memo but will likely contribute to a larger error bar.
Direct DAPL sampling from Multi-port wells	1 ft screened interval (sand pack)	1.5 ft to 6.5 ft	Distance from screens ranges from 0.5 ft to 4.5 ft away from DAPL surface

Even with an understanding of these limitations, the currently available Site infrastructure and sparse DAPL monitoring network do not allow for unequivocal determination of DAPL position, elevation and thickness. In the Main Street area, only one multi-port well (MP-03) exists and that well is located in the corner of the Main Street DAPL pool and is not sufficient by itself to monitor/cover the larger area. There are also a few nearby monitoring wells. However, these wells have a minimum of 10-foot screen lengths, which also limits the accuracy of any measurements. Therefore, limited data are available to accurately evaluate the height, position and chemistry of this (Main Street) DAPL pool which covers an area several acres in size. More monitoring infrastructure is already in place at the Jewel Drive DAPL pool to support the ongoing DAPL extraction pilot test there. Two multi-port monitoring wells (ML-1 and ML-2) and two induction logging wells consisting of solid PVC filled with distilled water (ILW-1 and ILW-2) are located within 50 feet of the extraction well (EW-1). For well screen details, see Table 1 and Table 2 attached. For well configuration at the Jewel Drive DAPL pool, see attached Figure 2-1 from AMEC, 2014. This information has been used to develop a recommendation, below, to perform a limited scope investigation to clarify current DAPL mass configuration in that area as well as the comparability/accuracy of the various DAPL measurement methods (See Recommendations, below). Once completed, recommendations can then be made for implementing a robust DAPL monitoring program for other DAPL pools at the Site.

Recommendations:

1. *General Recommendations*: It must be acknowledged that Olin's CSM has remained essentially unchanged for over a decade. It must also be acknowledged that this CSM, as any CSM, must be periodically reexamined over time as new thinking, data, and technology come to the fore. Much of EPA's reexamination is based on more in-depth analysis of *existing* information. During this review, it has become apparent that much of the inertia behind the current CSM derives from a number of factors, such as:

    - Over-reliance on older data

- lack of new, updated, or confirmatory data
- Inappropriate or outdated data collection methods
- Equivocal or erroneous interpretation of existing data
- Measurement/assessment of key Site metrics by indirect rather than direct methods,
- Etc.

Any of these issues individually may result in ambiguous or erroneous conclusions, but in combination, the deleterious effects to the CSM may be significant. The overall approach for future data collection at the Site for assessment and remediation purposes needs to be updated/improved as follows:

- Institute regular monitoring of all key parameters and Site metrics in key locations critical to source control and site restoration;
- Update monitoring approaches to employ improved modern, direct-measurement methods;
- Understand accuracy and precision of all monitoring and data collection methods and employ methodologies appropriately in this context;
- Adopt and apply robust QA plans for all relevant activities; and
- Revisit previous conclusions by applying revised/alternative modern methods where appropriate/necessary.

2. *Main Street DAPL area*: As discussed in GC 8, above, additional data is needed to more accurately resolve the TOR surface in the Main Street DAPL area. Given the quality of the previous seismic reflection data, this method should be augmented to produce a focused "grid" of seismic reflection data which can be used to produce an updated and improved 3-D map of the TOR surface by employing a methodology which provides a level of *vertical resolution of 5 feet or less and lateral resolution of 50 feet or less in all directions*. Seismic reflection data should be collected using a relatively fine grid spacing, with a similar or closer geophone spacing as previous seismic reflection surveys (30 feet or less). A 50-foot grid-spacing between lines is proposed for the seismic reflection surveys as a starting point for discussions. However, it may be possible to reduce the density of coverage after discussions with geophysical contractors. A soil boring program, including confirmatory rock cores (e.g., 5 feet or greater), should be employed at least 10 percent of the seismic stations, including at all key locations, to confirm seismic-determined TOR depths. The attached Figure 6 shows the proposed area of supplemental coverage for discussion purposes, which is focused to the western margin of the Main Street DAPL pool, including the previously discussed "Saddle" and "Spillway" features as well as the newly-designated "Chalice", "Pinnacle", "Plateau", "Southern Slot" and "South Drainageway" features.

3. *Jewel Drive Top-of-Bedrock Surface*: In the interest of improving DAPL extraction effectiveness, it is also critical to perform additional efforts to produce a more highly resolved map of the TOR elevation relative to the following efforts in the Jewel Drive area: a) to provide a technically defensible foundation to a more robust, holistic analysis of extraction efforts to date; b) to support follow-up DAPL measurement assessments proposed in the recommendation, below, and c) ultimately to support design/installation of additional extraction wells or modification of existing wells as driven by the data. Experts from EPA's Office of Research and Development (ORD) have begun an in-depth review of work-to-date towards the goal of developing strategies for optimized extraction of DAPL related to the Jewel Drive pilot test.

Current recommendations suggest short screened-intervals for extraction points, of as little as 1-ft in the vertical dimension may be more effective in allowing for sustained extraction. In this context, the need for a more highly resolved map of the TOR surface at Jewel drive becomes a high priority design data objective. A similar approach to that requested for the Main Street Area, above, is a starting point for discussions, but a higher level of resolution may be needed in the Jewel Drive area to support remedial design, including more precise placement of extraction well screened-intervals relative to TOR and DAPL elevations. A review of existing TOR data across the Site suggests that a methodology and implementation strategy which provides a level of vertical resolution of 2-feet or less and lateral resolution of 10 feet or less in all directions may be needed to achieve design objectives. Seismic reflection data should therefore be collected using a relatively fine grid spacing and tight geophone spacing. A 10-ft X 10-ft grid-spacing is proposed for the seismic reflection surveys as a starting point for discussions. The area to be surveyed at the specified higher resolution should minimally be a 200-ft X 200-ft box centered on EW-1. However, given the relatively high data density in the Jewel drive area, it may be possible to reduce the density of seismic reflection coverage after discussions with geophysical contractors. A precursor to these discussions will require an in-depth assessment of data quality ('error bar', accuracy, and precision) inherent to the current data set used to produce the best currently-available TOR elevation map in the Jewel Drive area. A soil boring program, including confirmatory rock cores, should be employed at least 10 percent of the seismic stations, including at all key locations, to confirm seismic-determined TOR depths. Please see also GC 9, above.

4. *Improved Methodologies needed for DAPL Measurement*: Induction logging and multi-port sampling (for all DAPL-specific indicator parameters) should be combined with a field profiling program that includes electrical conductivity logging, such as a membrane interface probe or equivalent, collection of co-located groundwater profiling samples at approximately the same elevation as nearby multi-port wells and from equivalent depths at selected locations between these elevations, and collection of co-located soil samples.

   Specifically, we note that the DAPL pool at Jewel Drive is instrumented with two induction logging wells (ILW-1 and ILW-2) and three multi-port monitoring wells (ML-1, ML-2, and MP-2) in addition to traditional screened monitoring wells (GW-42S and GW-42D). These should be included in an evaluation of DAPL and soil characteristics to develop a more complete understanding of the electrical conductivity of the soil and to provide more resolution than is available with the current multi-port wells. Therefore, an additional direct-push technology (DPT) drilling program should be considered that would include the following:

   A) Creation of a more highly resolved map of the TOR surface in the Jewel Drive area, particularly the area within a 200-ft radius from EW-1, is a necessary first step to evaluating DAPL elevation and thickness in a more technically defensible manner; see previous recommendation, above.

   B) Soil sampling to evaluate concentrations of DAPL contaminants and the presence of precipitates that may cause false positives for induction logging. A method which can provide continuous soil profiles through depth intervals of interest is needed.

C) Groundwater profiling using a technique capable of relatively fine vertical resolution (such as a Waterloo® profiler) to evaluate groundwater concentrations at the same elevation as the multi-port wells and at discrete depth intervals between those elevations. A 2-ft vertical discretization interval (or less) between samples is recommended, at least in critical areas and depth intervals.

D) Electrical conductivity logging to compare soil and groundwater profiling results to the induction logging well results.

The DPT drilling should be performed in the immediate vicinity of the multi-port and induction logging wells, and then at set distances away (recommend 50 feet, 100 feet, and 200 feet) to determine the horizontal variability in these measurements. Comparison of these different data sets at Jewel drive will help to determine DAPL and soil characteristics in and above the other DAPL pools.

After the more data-rich Jewel Drive DAPL pool is more highly resolved and improved methodologies are implemented for time-series measurement of DAPL elevation and thickness in key locations, a similar reassessment of the DAPL pool(S) in the Main Street Area, with the benefit of the updated TOR mapping included in recommendation 2, above, will be needed.

References:

AMEC, 2014. DAPL Extraction Pilot Study Performance Evaluation Report, Olin Chemical Superfund Site. November 7.

Amec Foster Wheeler, 2018. Draft Remedial Investigation Report, Operable Unit 3, Olin Chemical Superfund Site. March 30.

Olin, 2008. Boring and Well Logs, Olin Chemical Superfund Site. February 26.

Attachments:

Figures 1 through 9

Figures to Accompany EPA Memorandum Entitled:

Improving Resolution and Technical basis for CSM relative to Main Street and Jewel Drive DAPL pools, OCSS, Wilmington, MA: Recommendations to Support Source Control Remedial Design, November ~~28~~, 2018 (Actual Memo date is November 29, 2018)

Revised CSM for Main Street DAPL Pool and Related Features

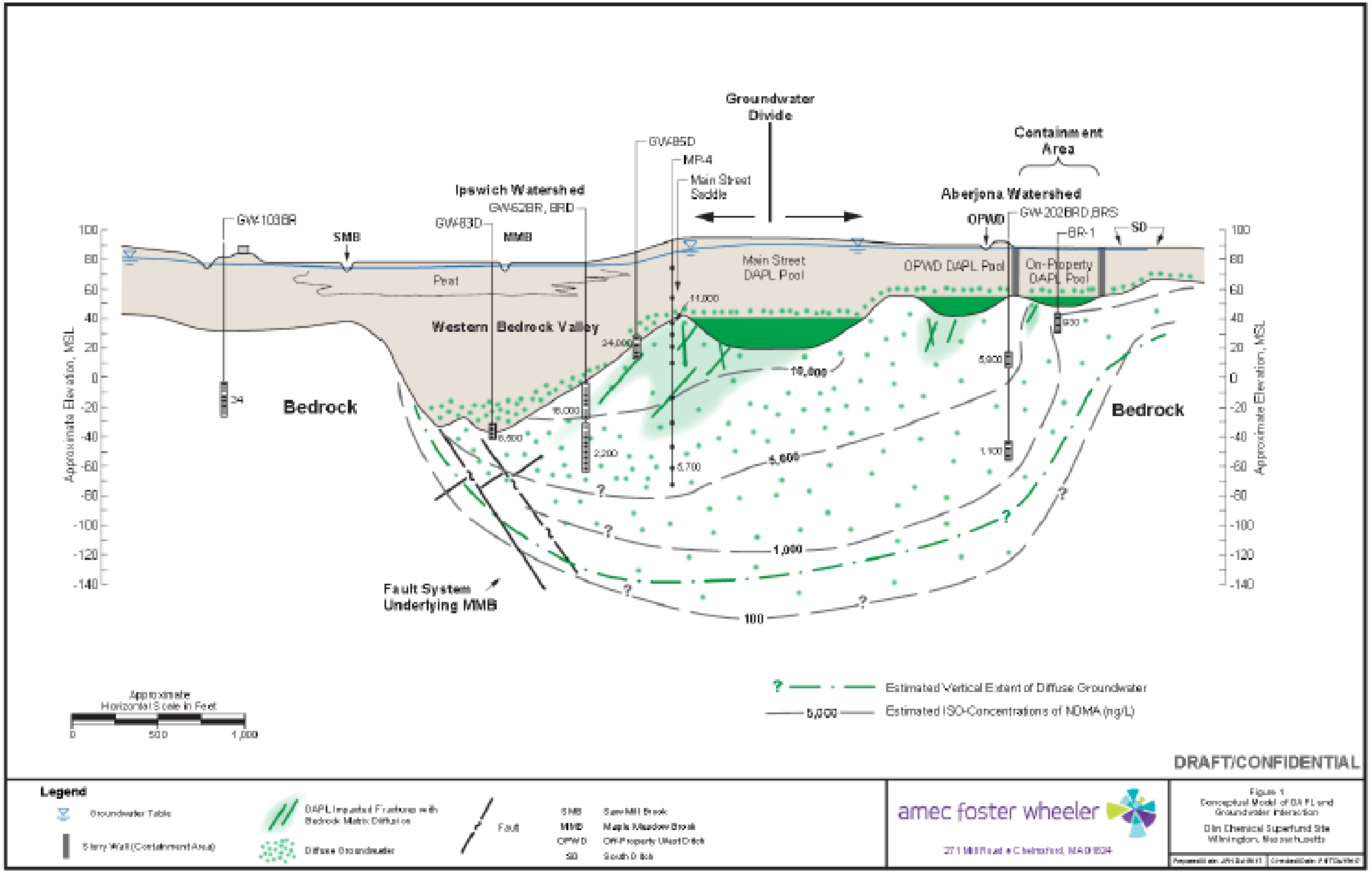
W. C. Brandon

November 28, 2018

V 1.0

Figure 1a.

Conceptual Model of DAPL / Groundwater Interaction in Underlying Fractured Bedrock



Revised General CSM Model for DAPL Pool (e.g., Main Street DAPL area) Showing Measurement Uncertainties on DAPL surface and TOR Surface

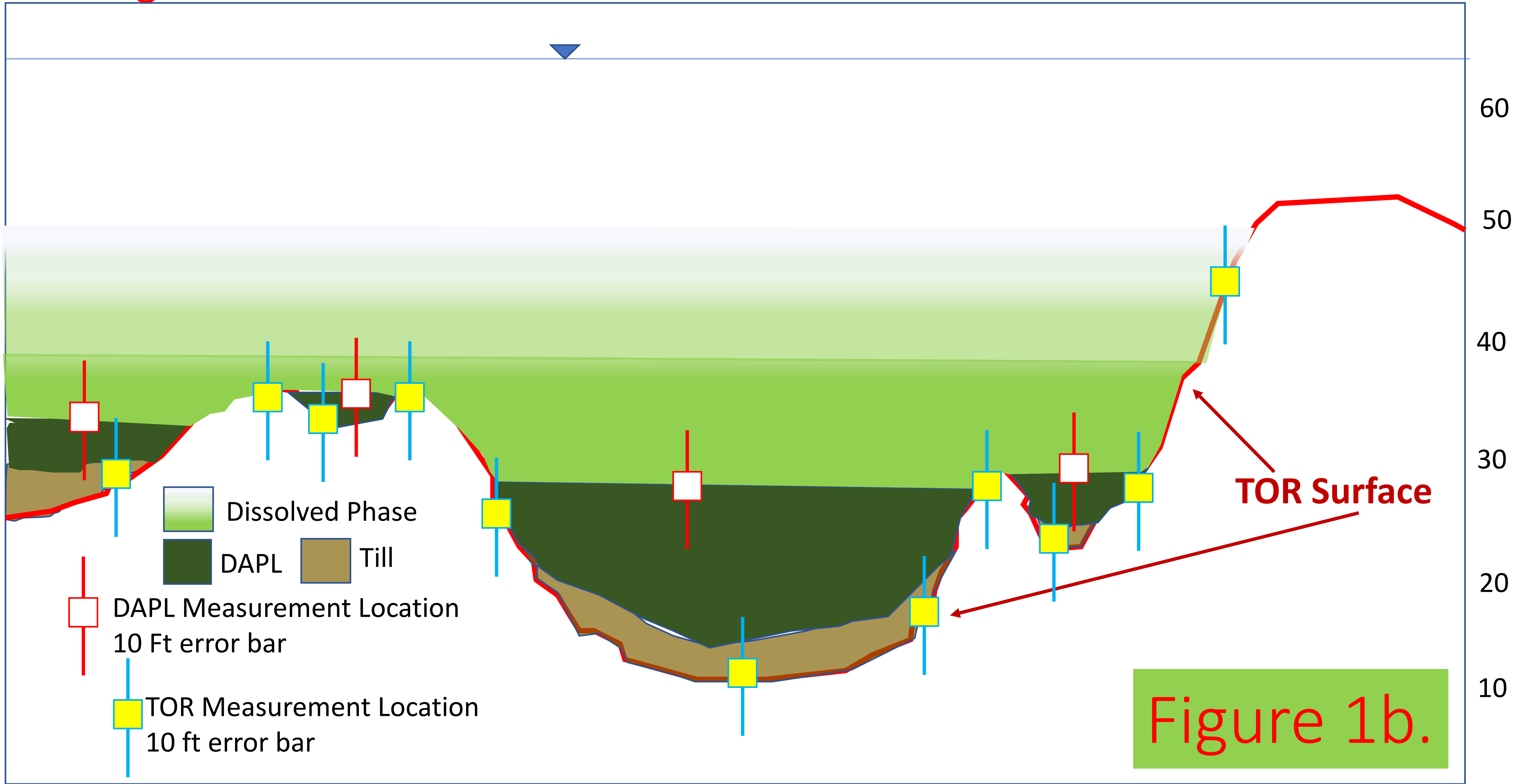


Figure 1b.

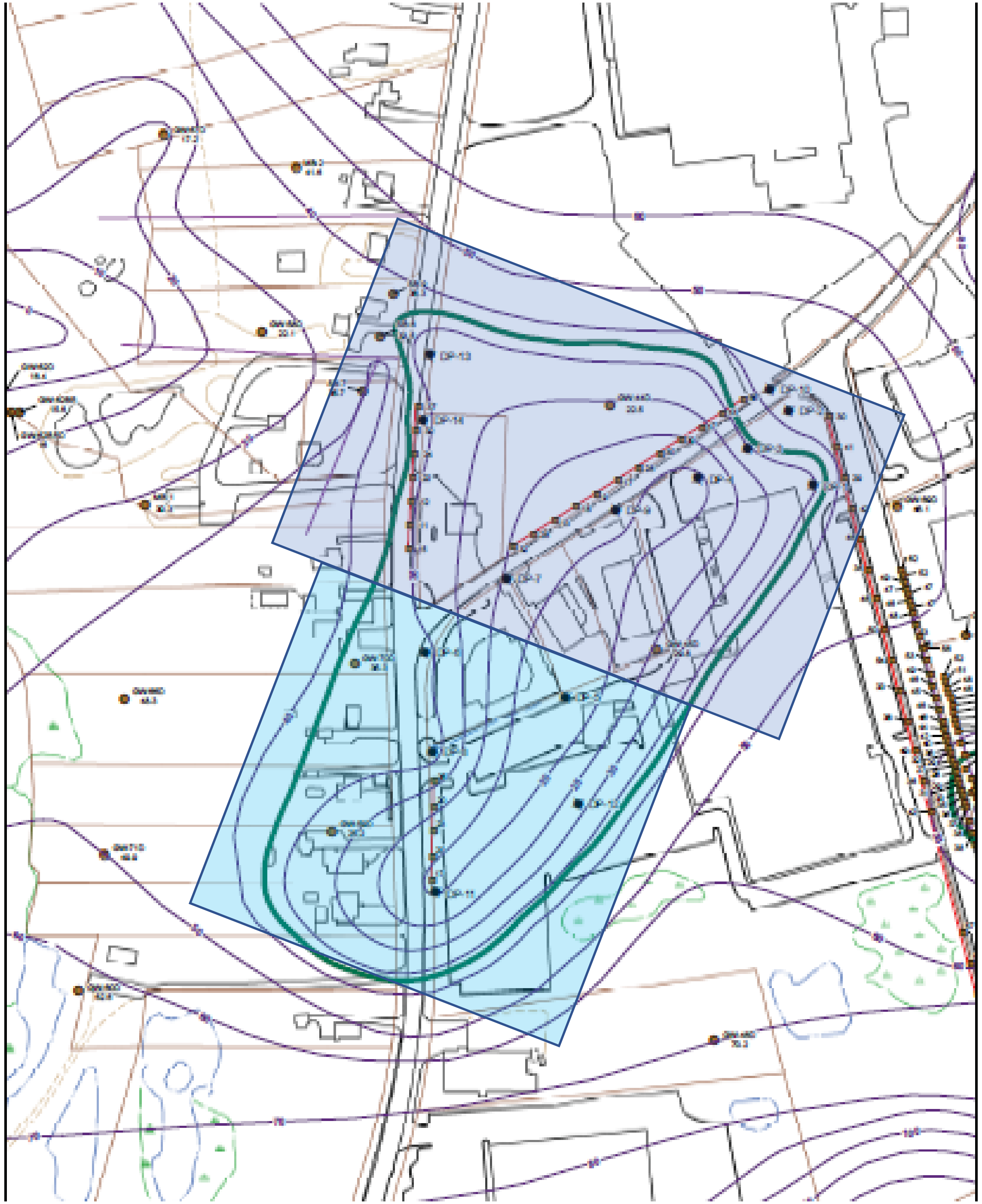


Figure 2

- BOX 1 (North): 9.9 acres
- BOX 2 (South): 6.3 acres

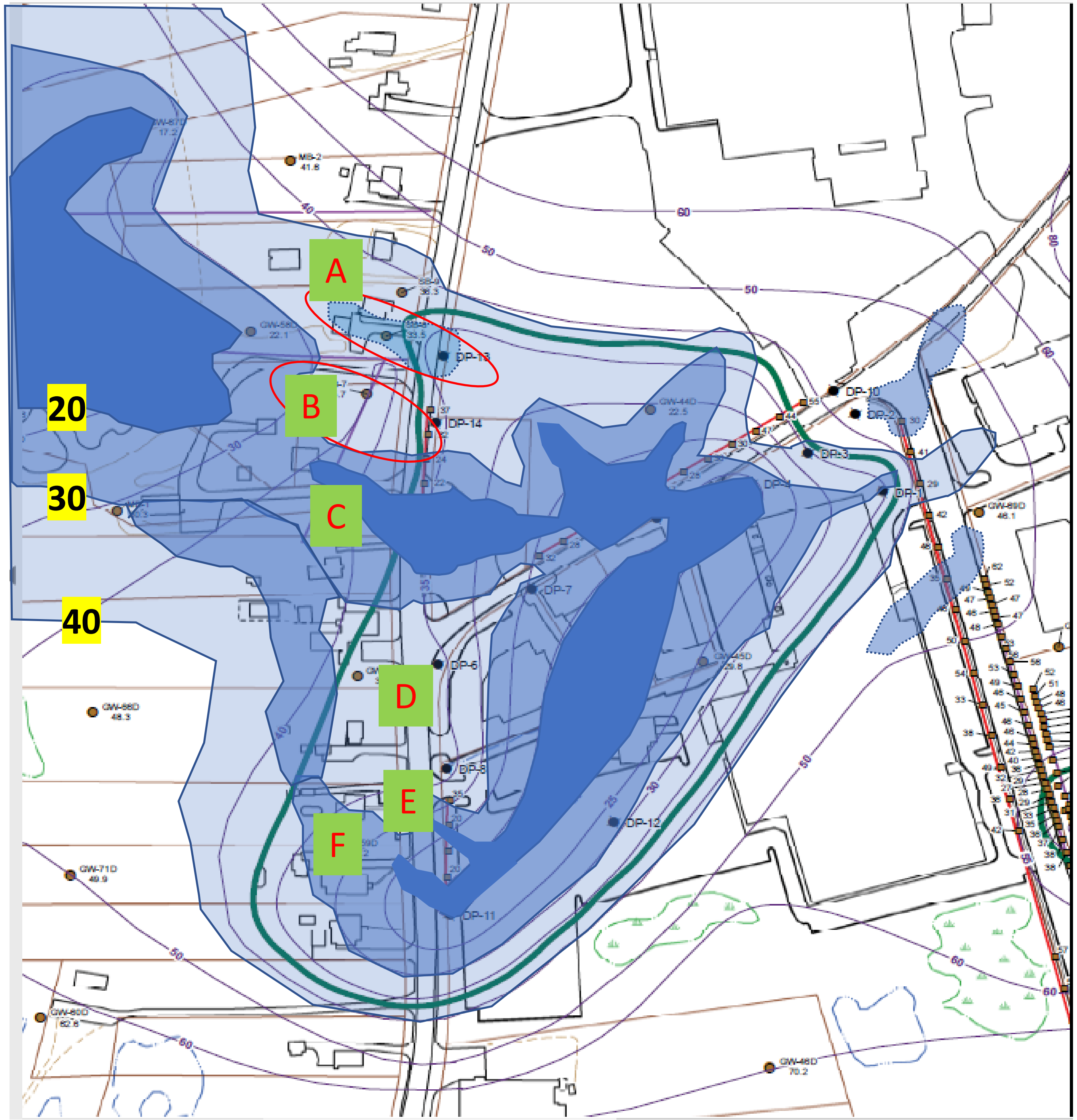
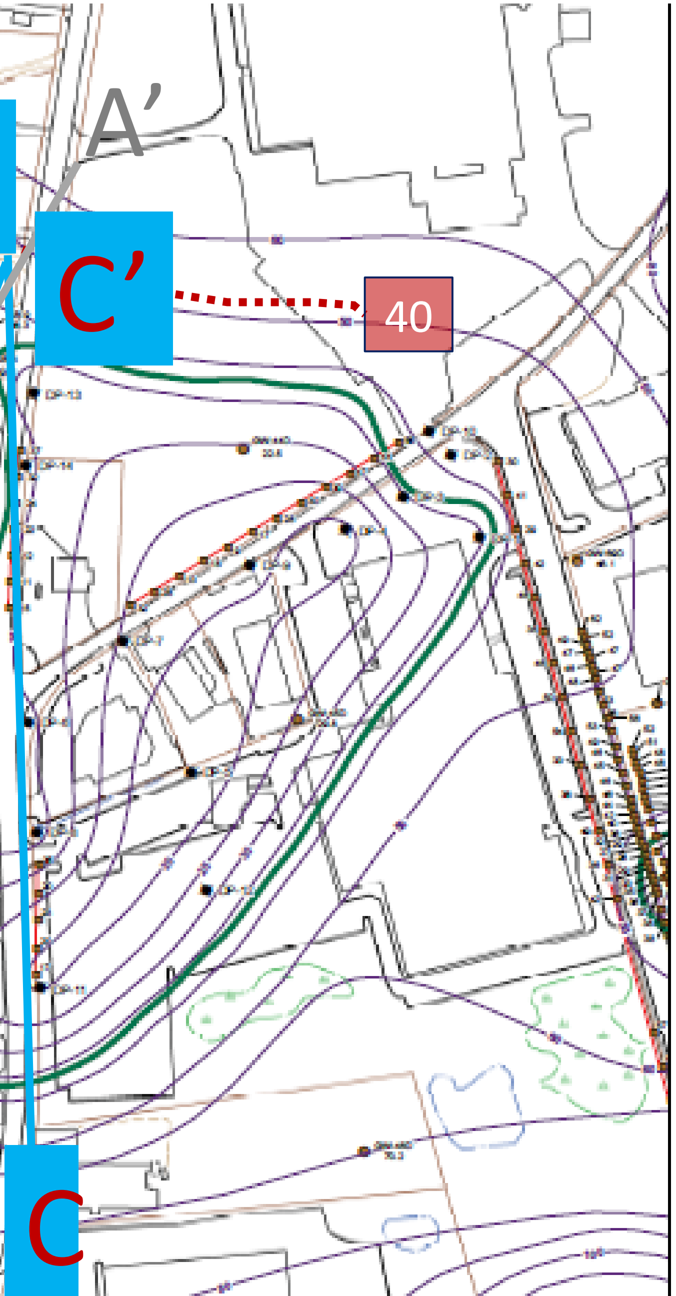


FIGURE 3

- A – “Chalice” (elev. < 35 ft amsl)
- B – “Pinnacle”
- C – “Spillway”
- D – “Plateau”
- E – “South Slot”
- F – “ South Drainageway


A'
C'
40
C

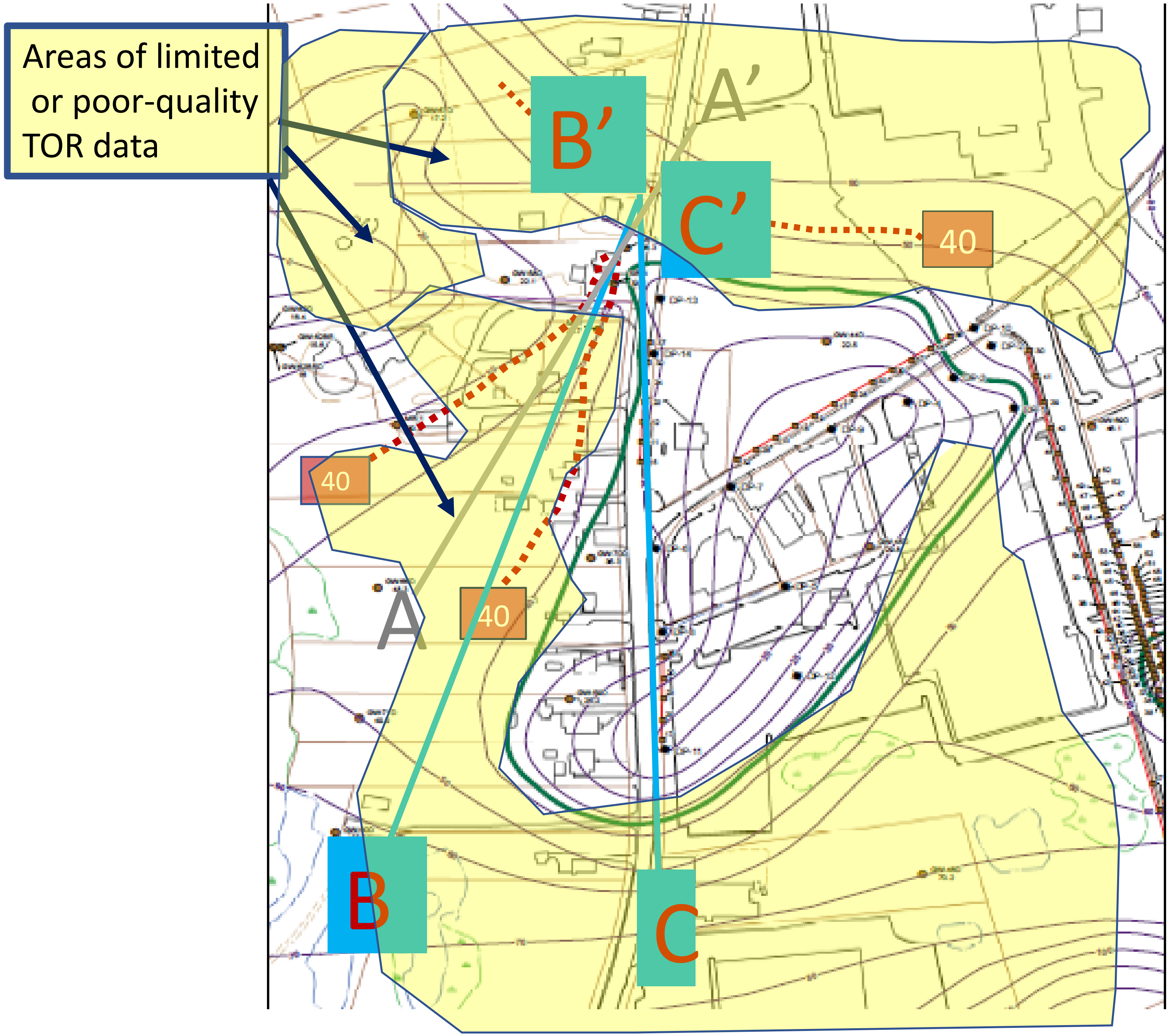

Areas of limited or poor-quality TOR data
B'
A'
C'
40
40
A
40
B
C

Figure 5 - Cross Section B-B’

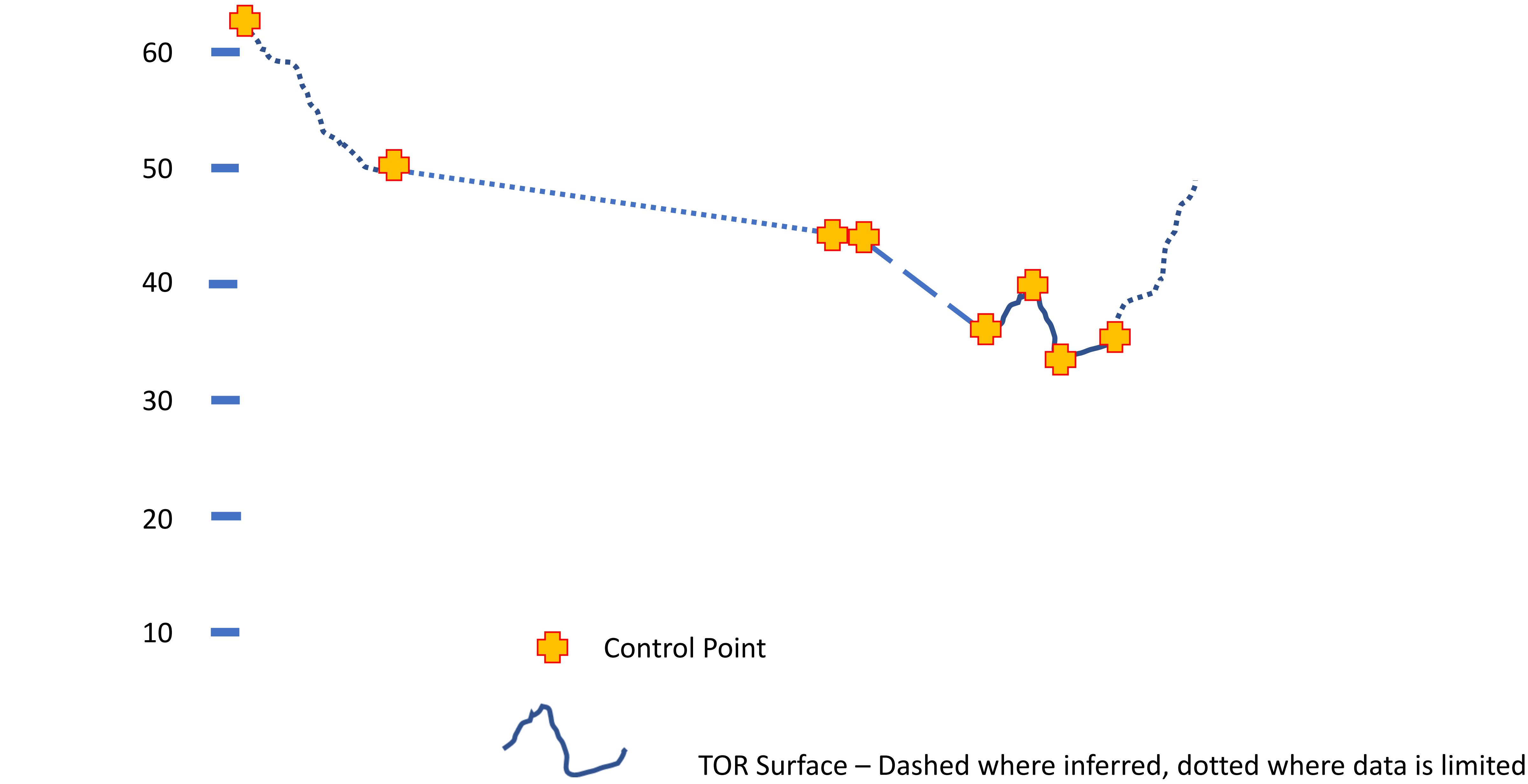


Figure 6 - Cross Section C-C’

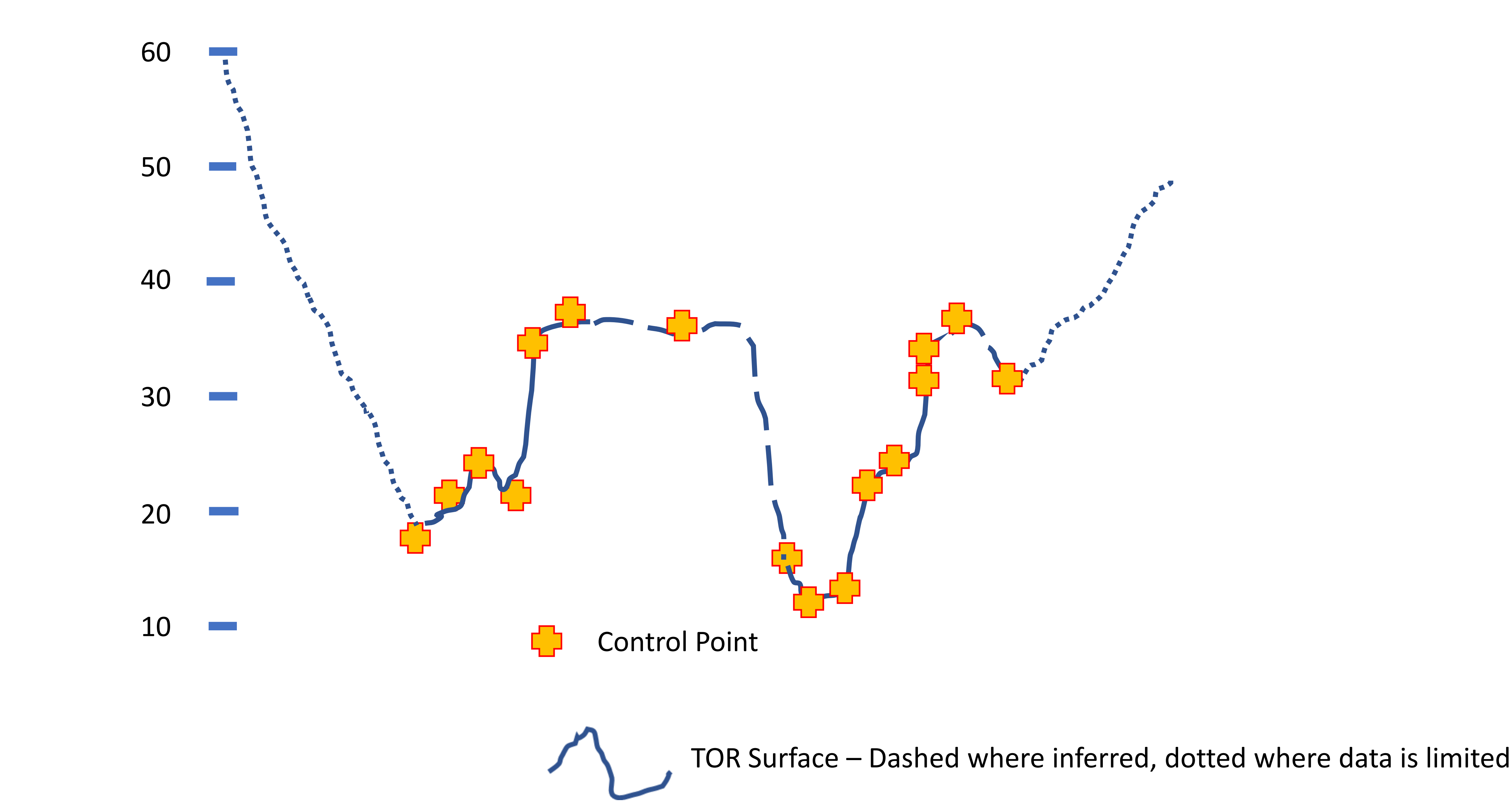


Figure 7 – Areas Proposed for Additional Seismic Reflection Surveys